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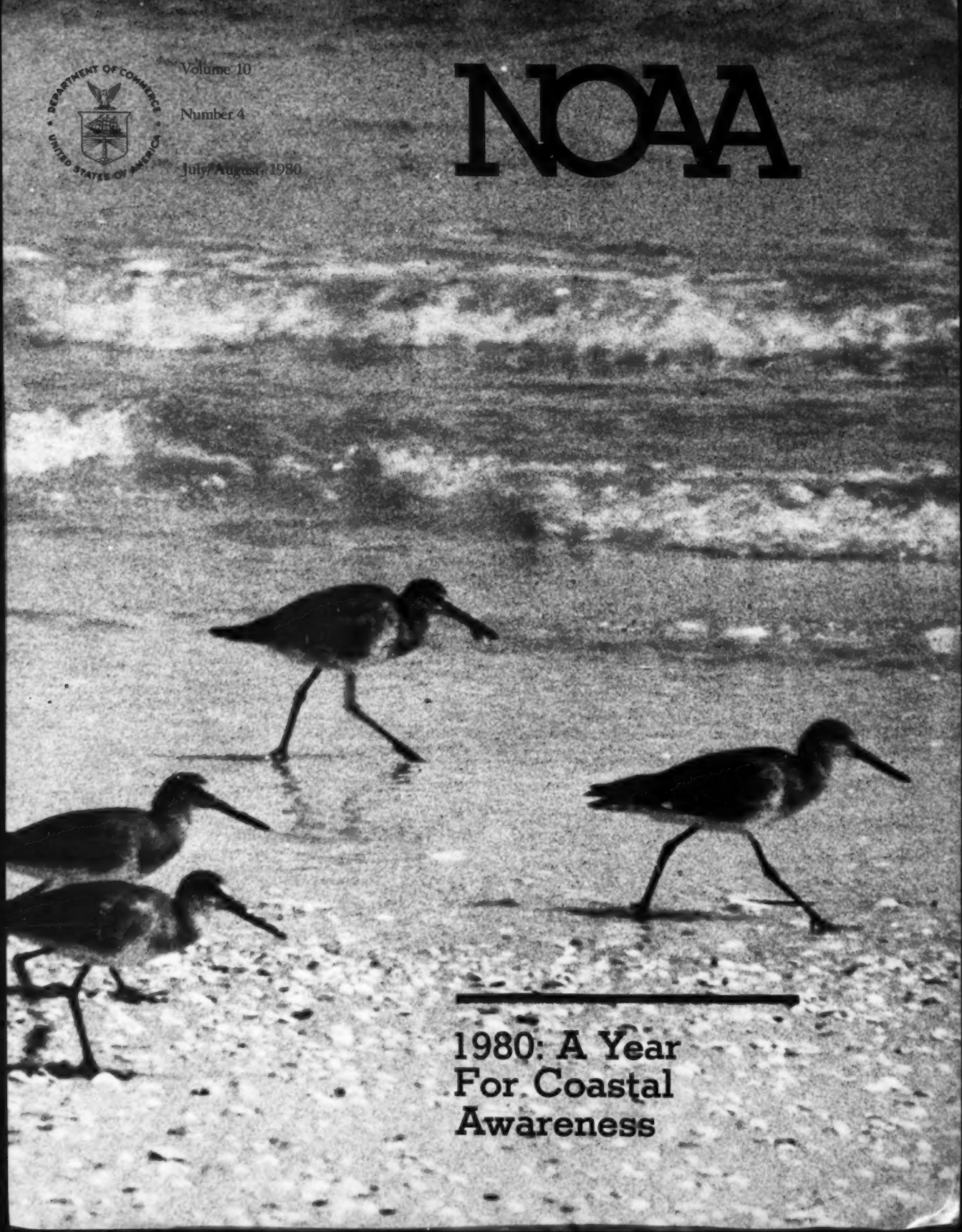

1980: A Year For Coastal Awareness

Pacific Gas and Electric Co.

Volume 10

Number 4

July/August 1980

NOAA

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The Geysers Power Plant, largest geothermal power facility in the world. *(See story p. 10)*

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COVER

Sanderlings scuttle in tidal wash, a common sight along America's beaches as people celebrate 1980: Year of the Coast

Bernard Brandt

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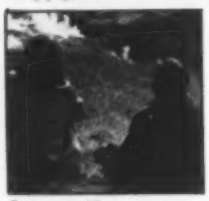

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Year of Decision for Marine Sanctuaries

Michael Glazer
Assistant Administrator for Coastal Zone Management

The Year of the Coast is critical for the important and controversial marine sanctuaries program. By the end of 1980 we hope to demonstrate that marine sanctuaries can, by providing special status and focused management, protect particularly valuable and unique marine areas.

Created by Congress in 1972, the program authorizes the Secretary of Commerce to preserve or restore the conservational, recreational, ecological, or esthetic values of special ocean areas that contain distinctly valuable resources and that are subject to cumulative human uses posing threats to their long-term preservation. Creation of a sanctuary ensures that it is managed with the primary goal of protecting it for future generations.

Until 1977 the program was only moderately active. No funds were appropriated for administration. Two sanctuaries were designated—the site of the USS *Monitor* wreck off North Carolina and the Key Largo Marine Sanctuary adjacent to Florida's John Pennekamp Marine Park. In 1977 President Carter instructed the Secretary of Commerce to step up the program. Since then, NOAA has undertaken two major efforts—developing a nomination process to identify appropriate sites and ensure that designations were sound, and designating some sites as sanctuaries.

Only the best candidates survive this process. For the past year NOAA has worked on several areas that appear to merit sanctuary designation—two areas off California (waters near the northern Santa Barbara Channel Islands and off Point Reyes and the Farallon Islands), Looe Key Coral Reef off Florida, waters southeast of St. Thomas in the Virgin Islands, Gray's Reef off Georgia, and the Flower Garden Banks in the Gulf of Mexico.

Each contains valuable, distinctive, and vulnerable marine resources that would benefit from the long-term comprehensive management of the marine sanctuary program. All will be subject, if designated, to monitoring, assessment, research, and education activities that not only will help preserve them but will also increase our ability to understand, appreciate and enjoy them.

Activities at the Key Largo sanctuary illustrate the activities that designation can stimulate. In accordance with its 5-year protection and management plan, NOAA sponsored a major survey of the sanctuary's deepwater resources, where scientists got a detailed look at resource composition, and for the first time located and mapped an extensive deepwater reef. NOAA also contracted for a geological baseline assessment, a biological baseline and reef health assessment, and a water quality inventory. The Florida Department of Natural Resources, which provides on-site management of the sanctuary, agreed to employ a full-time biologist to monitor environmental conditions.

The program attempts to manage valuable ocean resources in a new and controversial way. Some people are concerned that existing uses of sanctuaries, such as fishing or hydrocarbon development, might be unreasonably restricted. Others are concerned that the program will turn out to be only an added layer of Government regulation, accomplishing too little with funds that could be used for other purposes.

In the context of our overall national approach to ocean resources, the marine sanctuary program provides a small but necessary balance to an expanding ocean development program. As efforts to develop and use offshore resources increase, we must take a careful look at special marine areas where protected status may be appropriate and where, perhaps, development should be restricted to preserve irreplaceable resources, where education and information can be made available to enrich our experience and awareness of their value, and where research can be conducted to assure maximum safe use and enjoyment.

Giant Cracks

Brian Gorman

A YEAR FOR COASTAL AWARENESS

The U.S. coast, all 95,000 miles of it, winds its way around 30 of our 50 States like a convoluted membrane protecting an enormously complex cell. And like a real cell membrane, the coast has interstices through which transpire the wastes and nutrients—the life forces of the cell within—to and from the waters of the Atlantic, Pacific and Arctic Oceans, the Gulf of Mexico, and the Great Lakes.

The sad fact is, however, that in spite of its importance to trade, to transportation, to defense, and to recreation, the coast seems to many of us a passive, inconsequential border between the land and the sea to be pushed and bullied when the need arises but otherwise to be ignored. Not that we don't respond to the hurly-burly of a New York or the beauty of a Big Sur. It's just that the response so frequently seems to be of the coffee table picture book variety: to be gaped at for the moment and then to be forgotten.

But letting us forget the coast isn't exactly what the Coast Alliance, a broad coalition of environmental and other groups (Sierra Club, National Wildlife Federation, United Auto Workers, and League of Women Voters, to name a few) had in mind when it started moving last year to make 1980 the Year of the Coast.

The driving force behind the idea, according to Bill Painter, Executive Director for the Washington, D.C., based organization, was concern among members of a number of national environmental groups with the deterioration of coastal areas. "It was clear that there was a great need for diligence along the coast. The idea (for a Year of the Coast) was formalized in early 1979 at a series of national meetings," according to Painter.

K C Smith

The photographs illustrating this article are from the poster: 1980—Year of the Coast.

Given a big boost by President Carter's endorsement of the idea in his environmental message last August, the Coast Alliance began building bridges between State and local groups representing a highly diverse community of ordinary citizens, on the one hand, and policy makers in the Federal Government on the other. The National Oceanic and Atmospheric Administration quite naturally became the clearinghouse for Federal coastal activities, coordinating both Federal agency work and work in the States. In addition, NOAA made a commitment early on, through its Office of Coastal Zone Management, to provide money for Year of the Coast activities to outside, nongovernmental groups. Ninety thousand dollars has already gone to the League of Women Voters Education Fund for use by qualified local groups.

"We're also providing a lot of in-kind support," says Catherine Morrison, NOAA's Year of the Coast coordinator. "One of the biggest things we've been doing is bringing NOAA's research ships into ports for public visits, usually in conjunction with a harbor festival."

Since April, when the *Rainier* was in Seattle for an open house, NOAA ships have participated in more than a dozen such events, including the Spoleto Festival in Charleston, S.C., Boston's 350th Jubilee, and a Norfolk, Va., Harborfest.

In New Jersey, Adele Gravitz, public participation and education coordinator for the state's Division of Coastal Resources, has a straightforward, but challenging, job ahead of her. "What I've got to do over the next several months is reach out to people who might otherwise not even know about their coast," she says.

"Ultimately everything comes down to a person-to-person level," she says, "and if New Jersey's citizens don't know what government is doing in the coast, for example, they're not going to be in any position to help make public policy."

Public policy seems to be at the back of a lot of otherwise entertaining events tied to Year of the Coast.

"We know of about 600 coastal events that have either already taken place or

Grant Goodge

Roland Paine

Rouse Company

Bob Williams

are planned for 1980," says Coast Alliance's Painter. "And almost every one of them provides a chance to educate people and to influence the way they see themselves in relation to their coast."

So where does public policy come in? Painter thinks consciousness raising ought to go beyond mere education. "If people know about (coastal) problems but don't do anything, it's kind of a waste." Clearly, in Painter's view at least, all those posters and seafood festivals and beach walks are only the beginning of what he calls a "new community" of coastal activities.

Creating new communities can sometimes be tough, however. Wisconsin, for example, even though it has a shoreline in excess of 500 miles, is not perceived, either locally or nationally, as a "coastal state."

"There isn't the sense of coastal awareness in Wisconsin that you'd expect," says Ellen Fisher, coastal management specialist for the state's Coastal Management Council.

"What Wisconsin does have," says Fisher, "is a very environmentally-conscious citizenry. If we can make them coastally concerned as well, we'll have something going."

The difficulty of a State's "coastal identity" is borne out by comments from Michigander Joan Dent, Great Lakes regional coordinator for the Coast Alliance. "Identification varies enormously from state to state," she says. "This isn't surprising when you consider that Michigan —where coastal awareness is strong—has one of the longest coastlines in the country. And right next door is Indiana, with a tiny coastline—some out-of-staters don't know Indiana even *has* a coastline—and a commensurately low coastal identification."

Dent bears out Ellen Fisher's observation that environmental concerns in general, if not coastal issues in particular, are high priorities for Great Lakes residents.

"Throughout the Great Lakes states, especially Wisconsin and Michigan, there are very many environmentally aware groups and organizations," Dent asserts. And, she adds, many of their concerns are directly related to the Great Lakes, and hence the coast: winter navigation, toxic substances (like PCBs) in food fish, erosion. In fact, the governors of four Great Lakes states—Wisconsin, Michigan, Ohio, and Indiana—have issued proclamations endorsing 1980 as the Year of the Coast. Fluff perhaps? Not to hear Dent talk.

"Measured in issues there is remarkable support from lots of different groups throughout the region," she says. One subject on which there is broad support and which should be going somewhere next October, is a "coast day" in schools across the region. Working through the League of Women Voters, Dent and her counterparts in other states hope to have October 3 declared a special day in which youngsters not just in Cleveland and Chicago and Duluth, but inland as well, would devote part or all of the school day to coastal issues.

The idea already has support from inland counties and boards of eduction. "If success is measured by how many activities you've got going," asserts Dent, "then 'coast day' will be a smash. We've got lots of education material developed."

Six hundred miles away, in South Carolina, public awareness isn't the problem, directing it is. John Armstrong, executive director of the State's Year of the Coast Committee and director of South Carolina's Sea Grant Consortium, claims that South Carolinians are more than usually aware of coastal issues.

"That makes our job a lot tougher, ironically," says Armstrong, "because people are so well informed, they tend to demand more of their public officials, including those, like us, who are in the job of education."

If the State does half of what Armstrong plans, South Carolinians will have no cause to complain about not being informed about the issues. Planned or already completed are a series of TV spots on the Year of the Coast done by the state's Sea Grant Program, beach walks, the Spoleto Festival in Charleston, and a series of public seminars on Year of the Coast issues.

"I'm very pleased about the seminars," Armstrong says. "We've already had one on barrier beaches—very well attended—and plan four or five more on some equally tough coastal issues."

Armstrong is also particularly pleased, in fact almost ebullient, about an upcoming issue of "South Carolina Wildlife," a popular wildlife magazine that many people put on a par with "Audubon." The entire issue this summer, about ten articles, will be devoted to Year of the Coast.

WHAT'S A NICE STATE LIKE YOU DOING IN THE COASTAL ZONE?

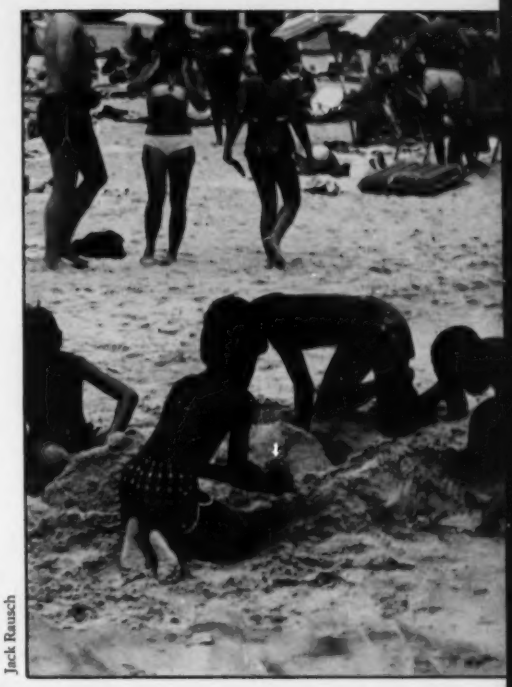
Ask the average person to name the coastal states and chances are he'll overlook entirely the states bordering the Great Lakes, even though their combined shoreline constitutes more than 5,560 miles, about 10 percent of the total of the Lower Forty-eight.

The truth is that when most of us think of the coast we think exclusively of the sea coast. We tend to forget that Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio, Pennsylvania, and New York (the only one of the eight that has a saltwater coast) are as coastal as Maine or California.

Not only are the Great Lakes states recognized as coastal by law—through the Coastal Zone Management Act of 1972—they behave coastally as well. They have "tides," although caused not by the moon but by the rhythmic sloshing back and forth of the lake water, a phenomenon known as a seiche. They have shoreline erosion problems, especially in Michigan, exacerbated by the crush of winter ice every year. In fact, all the thorny coastal management issues faced by the seaboard states—recreation, beach access, sport and commercial fishing, preservation and development—are just as critical in the Great Lakes states.

In addition, the Great Lakes states have their own set of unique coastal problems. Because the Lakes are freshwater rather than salt, their surfaces freeze solid for much of the winter. The advisability of using ice breakers and bubble making machines to keep navigation channels clear is being questioned because of high costs and their contribution to shoreline scouring. And shipping itself in and out of the Great Lakes is limited because of the 27-foot draft restriction in the St. Lawrence Seaway, shallow for such an enormous industrial area.

Finally, because the Lakes are to a large degree a closed system—Lake Superior takes about 600 years to flush itself—the presence in the water of toxic wastes and chemicals and their effect on fisheries and recreation is much more important from a managerial point of view than it is along most of the seaboard states.



Jack Rausch

"And," adds Armstrong, "they'll be printing an extra 25 thousand copies."

What will happen when 1980 Year of the Coast slips into 1981 Year of Something Else? When Lake Michigan is frozen over and there's snow in Norfolk, Va., and the grunions are running in Southern California will anyone care about what happened during the Year of the Coast?

If the Year of the Coast accomplishes anything meaningful it will have more to do with perceptions than with events, more with attitudes than festivals. And perceptions and attitudes, even for a sociologist, are awfully difficult to measure.

Adele Gravitz from New Jersey put her finger on both the unquantifiability of what the Year of the Coast may accomplish and an excellent reason for working as hard as possible on Year of the Coast events just the same.

"We're really dealing with people," she said, "educating them, showing them how the coast works. Even if you lose 99 percent of them, it's the one percent that you reach that really counts."

Ralph Kresge

Pacific Gas and Electric Co.

From steam baths to energy source

CALIFORNIA'S GEYSERS SPOUT RESEARCH

Gold was not the only mineral that attracted thousands of people to California during the last half of the 19th century. Sulfur and other lesser-known minerals, dissolved in underground springs, were invisible drawing cards at health resorts in the Geysers area, 100 miles (160 kilometers) north of San Francisco.

From the mid-1800's to the 1920's, the hilly regions of Sonoma, Napa, and Lake counties drew countless believers in the medicinal value of sulfur baths to Calistoga—the Saratoga of California—and other spas.

Today, the resort area beckons another breed of prospectors—those in search of alternative sources of energy to sate the nation's appetite for electric power.

Fueled by an underground reservoir of steam estimated to be at least 10 square miles (26 square kilometers) in area, the Geysers geothermal region is nestled in the rugged Mayacmas Mountains, south of Clear Lake, near Cobb Mountain. There, about 2,500 feet (760 meters) above sea level, is the great Geysers power project, developed by Union Oil Company of California and Pacific Gas and Electric Company. It is the largest geothermal steam project in the world, and the only one in the United States. By 1983, 21 geothermal power plants, tucked among the pine and oak-covered hillsides there, will supply enough electricity for 1,500,000 people.

At present, energy production in the Geysers area is concentrated primarily in the northeast corner of Sonoma County where underground "pools" of dry steam rise through cracks in the rock and escape through natural surface openings, called fumaroles.

However, this "free" source of energy is available only with its own environmental signature—the perpetual odor of

hydrogen sulfide gas—commonly identified as resembling the smell of rotten eggs.

Although special equipment to eliminate over 90 percent of the hydrogen sulfide has been designed and installed at each of the generating units, a multi-year research project is in progress to check the remaining 10 percent's invisible journey. This project, with the acronym ASCOT for Atmospheric Studies in Complex Terrain, is a major Department of Energy program designed to develop an understanding of how air pollutants are dispersed in complex terrains and to develop and validate models to guide planners in choosing environmentally acceptable sites for new energy sources.

Though not believed to be a health hazard in the concentrations commonly found in geothermal steam, hydrogen sulfide is an annoyance because of its odor. The Department of Energy hopes to learn enough about the winds in the area to help advise energy officials where to locate future geothermal power plants to limit hydrogen sulfide pollution in the valley.

To pursue this early goal, NOAA scientists are using a variety of research tools to measure winds and temperature inversion layers—blankets of cool air lying near the earth's surface that can keep pollutants from dissipating.

Last summer they concentrated on surveying the nighttime air circulation in the valley. They completed an initial series of measurements of temperature, wind speed and direction, and other weather characteristics during a 2-week period in July. These test results have been analyzed in preparation for a month-long, more comprehensive series of measurements in September 1980 in the same valley and to help in the development of computer models to estimate the pollution flow pattern.

To determine the height of the temperature inversion layers that may form in the picturesque Anderson Creek Valley, the scientists use remote sensing instruments called acoustic sounders. One of the sounders, using a large, hexagon-shaped antenna resembling an inverted teepee, has been stationed permanently in the valley's interior since July 4, 1979, transmitting audible sound pulses into the atmosphere. The sound travels vertically as high as 2,790 feet (850 meters) and is reflected back to the instrument from temperature fluctuations, which are strongest in inversion layers.

. . . a chance to compare smokestacks: nature's vs. man's

"The time it takes for the sound to travel up and back from the layer is used to determine the height of the inversion," explains William Neff, a physicist with NOAA's Wave Propagation Laboratory.

The sounds, resembling intermittent bird-like chirps, can be heard a mile away on cold nights, but they are less audible during the daytime. The single (monostatic) sounder is connected to a microprocessor computer system, housed in a small portable structure, which records the information.

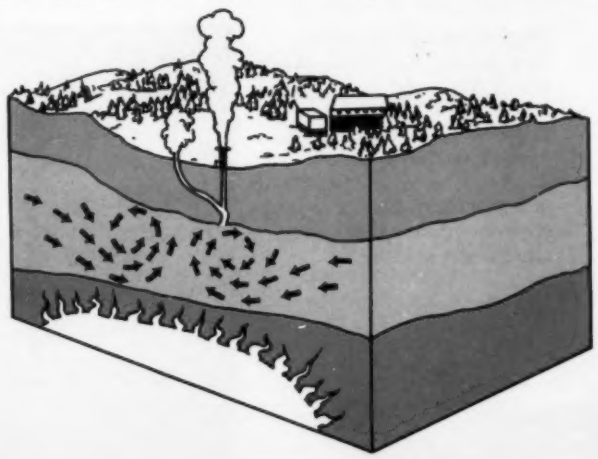
At the mouth of the valley is an array of three acoustic sounders. A central monostatic sounder antenna acts as a receiver for two transmitters, spaced 1,000 feet (300 meters) away at 90-degree angles. The two transmitters send sound pulses into the atmosphere above the central receiver. Using the frequency change of the return signal, a phenomenon known as the Doppler shift, the scientists can determine the wind speed and direction in 80-foot (25-meter) steps between heights of 165 and 1,970 feet (50 and 600 meters).

Since no remote sensors are available to measure temperatures in such inversion layers, the Boulder scientists and their colleagues from Battelle-Pacific Northwest Laboratory use bright red, helium-filled balloons to record temperatures. Suspended 2 meters below the miniature blimp-shaped balloon, which points into the wind, an instrument package contains a thermometer, a cup anemometer to measure wind speed, and a compass to track wind direction. A radio transmits information back to the ground as the tethered balloon is raised and lowered to give instantaneous profiles of wind and temperature conditions up to a half mile altitude.

In addition, scientists from NOAA's Atmospheric Turbulence and Diffusion Laboratory in Oak Ridge, Tennessee, are using small, spherical balloons, filled with just enough helium to be neutrally buoyant and float within an air current. Small, battery-operated lamps are attached to the balloons to make them visible in the dark. Throughout the night, these balloons are periodically released into the wind and tracked by two surveyors' instruments to determine the balloon's position as a function of time. Position observations at 30-second intervals enable the scientists to compute the balloons' speed and path.

"These observations allow us to trace the drainage wind currents in much the

Joan Vandiver Frisch



California geysers (opposite page) are steam from underground water heated by magma, the molten rock deep within the earth. Some of the geothermal steam finds its way to the surface through cracks in the underground rock and surface openings called fumaroles.

same way as buoys trace ocean currents," explains Carmen Nappo, a meteorologist with the Tennessee laboratory. "These data give us an idea of the speed of the current, its path, duration, and spatial extent. By observing the spread of the individual balloon paths as they move down the valley sides, we can estimate the dispersion of atmospheric pollutants in the drainage current."

Other means of visualizing the air current flow in the valley include the release and tracking of smoke-filled cannisters, activated by scientists from Lawrence Livermore Laboratory Environmental Systems and Services.

"The smoke sometimes shows the air flowing in layers out over the valley much like a layer of oil over water," Neff explains.

New chemical tracers, known as perfluorocarbons, have been developed by NOAA's Air Resources Laboratories, working with the Energy Department's Environmental Measurements Laboratory and Brookhaven National Laboratory, to simulate the movement, dispersion, and dilution of pollutants in the atmosphere. According to Gilbert Ferber, NOAA research meteorologist in Silver Spring, Md., the tracers will be released in the Geysers study area as colorless, odorless gases, harmless to man and his environment. An ultra-sensitive air sampling and analysis system has also been produced to measure these special tracers at concentrations less than one-millionth of the lowest concentration at which hydrogen sulfide can be detected. A release of as little as 10 kilograms of tracer (about 22 pounds) would be enough to detect 500 miles or more from the release point.

Two additional atmospheric tracers (heavy methanes) have been created by the Los Alamos Scientific Laboratory. These compounds, made specifically for use as tracers, are uniquely identifiable by mass spectrometry since their molecular weights are 20 and 21, compared to a molecular weight of 16 for ordinary methane. In the case of the heavy methanes even less material is required. As little as 100 grams would be required for a tracer experiment to a distance of 500 miles (805 kilometers). Five different tracers in all will be used in the September field studies, Ferber says, to simulate the build-up and dissipation of pollutant concentrations, particularly at night, when emissions from different geothermal sites may tend to pool together in the valley.

NOAA researchers say they have already learned many interesting things about the Anderson Creek Valley, and phenomena that might be put to work against pollution in the service of exploiting petroleum substitutes.

Before sunset, for instance, on a typical fair summer day, there is almost no variation in temperature within the first kilometer of air above the earth's surface. After sunset, however, the earth's surface begins to cool down, and a layer of cold air gradually builds up from the ground. Because the air is cooled, its density increases.

"If the ground surface is tilted and filled with hills and gullies, like the terrain in the Anderson Creek Valley, the cool air will flow downhill like mountain streams under the force of gravity," Neff explains. "When we have a local source of pollution such as the hydrogen sulfide gas emanating from the Geysers area, the pollutant will be carried in that drainage current of cooler air also."

"At the bottom of the valley this cool air begins to pool up much like water behind a dam," Nappo says. "Eventually the mass of cold air in the valley is sufficient to overcome forces that might be keeping it there and rushes out of the valley. The continuing drainage process then begins to build up another pool of cool air."

NOAA scientists hope to answer the basic question, "How does that air current behave?" Earlier studies had given only a partial glimpse of the current's behavior because only ground-based instruments were used. Now, using the acoustic sounding devices and balloons, NOAA scientists can define the depth of the colder air layer and measure wind speed and direction within it.

Drainage circulation figures heavily in the transport of pollutants in valleys, says Nappo. Air pollutants released near the ground at night can be "trapped" in a drainage current and transported with little dilution to the valley floor and communities such as Anderson Spring.

"This process can result in unacceptably high pollution levels which in turn can limit the exploitation of alternate forms of energy such as geothermal or oil shale development," Nappo explains. "Hence, the understanding of nighttime valley circulations is not only of scientific interest but also a necessary step in the nation's energy program."

From these field tests, NOAA scientists have learned that a wide variety of conditions influence how air flows out of the valley, but a persistent pattern has emerged.

About mid-afternoon, breezes begin arriving from the Pacific Ocean and continue until 8 or 10 o'clock each evening. During this time, the winds, blowing from 11 to 33 miles an hour (18 to 54 kilometers an hour), ventilate the valley, cleansing the area of pollutants.

When the sea breezes cease, a nocturnal descending air flow sets up in the sheltered valley. Its behavior depends

NOAA, William Neff

Truck-borne acoustic sounder (left) operated by NOAA scientists in Anderson Creek Valley. It emits sound pulses that, by reflection from air temperature changes, measure speed and direction of winds and height of inversion layers. World's largest geothermal power plant (right) also operates in the valley.

upon all the other conditions within and around the valley. For example, weather within the small valley, no more than 5 miles (8 kilometers) wide is influenced by the same large-scale wind flow that affects the Northern Pacific Ocean and the North American continent.

The nocturnal drainage flow is also influenced by shifts in wind direction over the ridges bordering the valley. Furthermore, a cool blanket of air that builds up over a larger basin adjacent to Anderson Creek Valley may back up into the smaller valley, affecting the air flow pattern there.

Before three-dimensional nighttime valley circulations can be successfully modeled on a computer, says Nappo, the drainage flow must be understood and modeled. Once simple modelings of the currents are achieved, he adds, they can be plugged into general circulation models.

"While numerical models can't predict details of the air flow within an inversion layer such as that at the Geysers, the computers can portray the overall picture or integrated flow pattern in the valley," Neff explains. This pattern is the combined air current flow of all the little hills and valleys in the region.

NOAA's Doppler acoustic sounder array, located at the mouth of the Anderson Creek Valley, can "see" the integrated air flow emanating from the area, providing "ground truth" data to test and calibrate the numerical models that are being developed.

"Our acoustic sounder array also plays an important role in identifying the inversion layer's behavior because it has been running continuously since last July, producing a wind profile every 20 minutes," Neff points out.

"These data provide a climatology of the winds over a long time so that when the intensive measurements using many more instruments are made during September, we can check out how representative those measurements are."

At that time, two more Doppler acoustic sounders, supplied by the Department of Energy's Savannah River Laboratory in South Carolina and Argonne National Laboratory in Illinois, will be located in the valley to trace the wind flows.

In addition, NOAA's Wave Propagation Laboratory will coordinate the use of five or six more monostatic acoustic sounders to monitor the inversion depth over a larger area. The sounder data will be used by Lawrence Laboratory scientists to decide when and where to release chemical tracers. Air samples taken downwind from the release site will be analyzed to determine how the colorless gases spread out in the valley.

"Once scientists understand the air flow in the Geysers area, and develop the means to measure and model such flows in more general conditions, they can determine where new power plants should be built to avoid adverse impacts of pollution in other areas," Neff says.

The aim of ASCOT is really much broader than siting power plants in Northern California. According to Dr. David S. Ballantine, organizer of the ASCOT program, the Department of Energy anticipates extending this project to study dispersion in other complex terrain areas such as the oil shale areas of Colorado and Utah or the coal fields of Appalachia. "We hope that the methodologies developed in the Geysers experiments will find general applicability in these new areas and be used broadly in studying air quality problems. If that is accomplished, the initial ASCOT effort will have served its purpose well." ●

GEOTHERMAL MAPS AVAILABLE

Three large, full-color geothermal maps showing the western United States, Texas and Louisiana, and Alaska and Hawaii, have been produced by NOAA's National Geophysical and Solar-Terrestrial Data Center, part of the agency's Environmental Data and Information Service in Boulder, Colorado. The large, 2'x3', maps show graphically the known geothermal resource areas and other complementary information such as locations of interstate highways, major cities, and National parks and monuments. With funding from the Department of Energy, NOAA prepared the maps for the U.S. Geological Survey to increase awareness and encourage the use of geothermal energy resources in the United States. The maps are part of a publication, *Assessment of Geothermal Resources of the United States-1978*, edited by L.J.P. Muffler. Although the maps show geothermal resources from the Rocky Mountains westward and in areas along Texas and Louisiana, large parts of the coastal plain in the eastern United States also may be developed in the future. The NOAA map team in Boulder is currently compiling a thermal springs list, and a map showing the springs location, for the entire U.S.

The USGS publication, Circular 790, and the three existing maps (folded) are available free of charge from: Branch of Distribution, U.S. Geological Survey, 1200 South Eads St., Arlington, VA 22202. Unfolded maps are available separately for a charge of $2.50 from NOAA's National Ocean Survey, Distribution Division, C-44, Riverdale, MD. 20840. ●

Geysers power plant operates from geothermal steam; nonpolluting steam condensate rises from low stacks above plant.

Bernard Brandt

Bringing the kids to the coast

James C. Elliott

Georgia is the largest State east of the Mississippi River—a fact that comes as a surprise to most people. It is basically a farming State, planted with cotton, peanuts, tobacco, corn, soybeans, and pecans.

Its coastline is comparatively short—only 100 miles long—and 9 out of 10 of its more than 5 million inhabitants live 100 miles or more from the sea.

To this region of landlubbers, NOAA's Sea Grant Program is bringing the ocean—and diversity and breadth of appeal are making the educational venture work.

An ocean-related curriculum was devised and introduced to Georgia's school system. People became involved through undergraduate and graduate courses, teacher training, and specialized aid to 4-H clubs, minorities, and other groups. And institutions—the University of Georgia system and the State government—gave "outstanding support," according to Georgia Sea Grant Director Dr. Edward Chin.

Georgians have been getting to know the ocean since 1971 at stations affiliated with Georgia Sea Grant, such as the Marine Resources Extension Center at the Skidaway Institute of Oceanography, part of the State university. The center has an aquarium, exhibits, and a dormitory for visiting students, teachers, and other groups. Another is the University's Marine Institute on Sapelo Island, a picturesque barrier island that has won attention as a Presidential retreat.

During the last school year alone, more than 27,500 students from 70 of the State's 159 counties visited Georgia Sea Grant facilities. Some drove 5 hours to get there.

"We're not trying to develop a whole generation of marine scientists," said Will Hon, the program's education specialist for elementary and secondary

schools. "We're creating a new experience for them, weaving the sea in with the humanities, social sciences, economics, and the like . . . The kids come down here. They see the marshes. They catch crabs. They walk along the shore and find all these things they've never even heard of before, and they get interested.

"Their interest generates questions. Pretty soon, you've got these youngsters —who probably have thought of the ocean just as a place for recreation— recognizing, for example, that dumping pesticides into a stream in inland Georgia can have a detrimental effect on the ecology along the coast.

"This generates concern that gets expressed when they go back home . . . The message they take back can be important to all the people of Georgia."

. . . wiser public decisions about coasts and oceans

Dr. Chin believes visits like these help assure wiser public decisions about coastal areas and oceans.

Last summer a program for minority college students was begun. For 2 weeks

Jim Elliott

Two 4-H members inspect cluster of oysters that they collected during Sea Grant-supported trip through a coastal marsh.

TURNING LANDLUBBERS INTO SEA LOVERS

Photos, Jim Elliott

Members of 4-H Club watch a Marine Extension Specialist feed fish during aquarium visit; Education Specialist Will Hon (below) explains anatomy of a blue crab to 4-H clubbers.

Will Hon explains Sapelo Island forest horticulture to teachers participating in Sea Grant marine education course.

up to 12 hours a day, promising young students were immersed in lectures, lab work, and field trips. They learned about the marine environment, its plant and animal life, and the interactions among biological, physical, chemical, and geological factors.

Teacher training is another pivot. Launched 5 years ago in cooperation with the National Science Teachers Association, it boosts teachers' confidence "to be self-sufficient in teaching marine resources in the classroom," Dr. Chin says.

Hon, designer of many of the educational programs, adds:

"The teachers who come here take these courses to expand their horizons. Through their participation we stimulate a much greater flow of knowledge, not only to the students, but also to other teachers, and ultimately to the community."

Interviewed after fall semester had begun, the teachers seemed delighted with their summer sea course.

M. G. Whittle, a sixth grade science teacher at Jane Mason Middle School in Brunswick, learned a lot about the area along the coast, and "because of that knowledge, I've been able to translate it into terms the children understand much more effectively."

"Seeing first-hand how one thing in the environment affects another was quite impressive," explained John Terry Leggett, a science and physical education teacher at Richard Arnold High School in Savannah. "Even without an ecology course in my background, I've felt pretty comfortable presenting the material to the kids."

Leggett, also an artist, said he regularly makes an artistic presentation of his subjects: "I draw the birds, the flamingoes, and estuarine scenes as I discuss those topics. That really has grabbed the kids. They're much more able to relate to the material that way."

"Exposure to that type of scientific thought was very valuable," said Janet Pinkerton, a second grade teacher at Fort Stewart Elementary School. "I started with absolutely no knowledge of what takes place on the coast. It was my very first experience as a teacher in learning

Teachers inspect shell of a giant sea turtle on Sapelo Island (above), while 4-H Club members (below) get on-scene explanation of oyster physiology and ecology.

Will Hon examines and explains blue crab life and behavior to 4-H Club members in summer course (above); later the students squish out of a mud flat where they learned about oyster habitat and ecology.

about the values and ideas of a conservationist—someone who cares about ecology. I know I can do a much better job now."

Barbara Schuette, a Savannah High School science teacher and a microbiologist with some background in the field, said she had been "completely fascinated" with what she had learned. "Also," she explained, "I was able to bring a lot of material that I had collected along the beach back home. Even when Hurricane David came through, and we didn't have power for 48 hours, I managed to keep many of the animals alive."

Another project that has won widespread appreciation has been Sea Grant's 4-H Club marine education training. The 4-H youngsters spend part of their summer camp on the ocean, where they participate in experiments and collect animals and plants. Of the field trips, the most popular appears to be one in which they wade into the mud flats in search of oysters. Adventuresome and energetic, the youngsters end up covered in mud, most of it self-administered as a result of mud-throwing contests or the artistic temptation offered by knee-deep goo. Their counselors have learned to schedule this activity as the last event of the day.

Although the program is young, there have already been signs of mounting public concern about ocean-related issues. Says Chappelle Matthews, a retired 28-year veteran of the Georgia Legislature and former chairman of the University System of Georgia Committee, "Sea Grant has brought about a whole new concept of the oceans throughout the State. . .

"I'll tell you," Matthews concluded, "the Sea Grant Program has come a long way. The people in the marshes and along the coast are a suspicious group by nature. Some folks even accuse them of having closed minds. But Sea Grant—through its educational efforts and its marine advisory services—has changed a lot of attitudes.

"It's one of the best things going in Georgia, and the people down here, I think, would be ready to fight anyone who didn't agree." ●

Volcano as weather modifier

DOWN TO ST. HELENS INFERNO

Carl Posey

The great cones rise thousands of feet above the coastal range's low, worn serrations, dinosaurs among mountains, volcanic vestiges of a more violent period in our planet's evolution. From Seattle down to Portland, one is never really out of sight of these great, dormant volcanoes on a clear day. And one never quite loses the sense of living at the foot of these outsized mountains, mountains that loom so large their scale seems off to the naked eye, as if framed in a telephoto lens; their apparent nearness destroys perspective.

Seen from an airplane heading eastward from Seattle, the big three among the dormant cones step southward in an almost straight line—Rainier just south and west of town, and more than 14,000 feet high, Mount Adams, a 12,000-footer 200 miles farther south, and 150 miles south of Adams, Mount Hood hovering over Portland. They whisper the geologist's adage: "There's no such thing as a dead volcano, only dormant ones." True or false, the line of enormous cones glowering over the Cascades evokes fiery rivers and buried towns, Krakatoas, Pelees, Pompeis, and Jon Hall movies.

Another, smaller cone off to the west of Mount Adams, rises dramatically from relatively low terrain. This is Mount St. Helens, smaller and, at about 2,500 years, younger than the others. A lighter sleeper....

In March, St. Helens fitful slumber ended. As if starting from some geologic nightmare, the awakening cone began belching forth great clouds of dust, ash, rock, and steam. Thus began the first major volcanic eruption in the lower 48 States since 1917, when California's Mount Lassen erupted. The last before Lassen was St. Helens, in 1857.

The towering column of dust, volcanic gases, and ash rising from St. Helens was a smoke signal to American scientists, who have not had many opportunities to look at an erupting volcano on their own turf. Thus, as the dusty rain of material from the smoking cone settled over nearby logging camps and forests and towns, scientists began arriving on the scene—geologists and vulcanologists from government agencies and universities—along with journalists, TV crews, aerial sightseers, all there to look at an erupting volcano.

For NOAA's Dr. Rudolf Pueschel and his colleagues from the Air Resources Laboratories in Boulder, Colo., St. Helens held a slightly different kind of attraction. While Pueschel may feel an affinity for active volcanoes—he directed the climate-watching observatory on Hawaii's Mauna Loa for 2 years—the eruption in southern Washington meant a chance to compare smokestacks: nature's *vs.* man's.

Since the mid-1970's, Pueschel has led a team of scientists and engineers in a highly specialized study of how the effluents of fossil-fired power plants, refineries, and even automobiles, affect the atmosphere, and vice versa. Their research focuses largely on a natural process called nucleation, a microscopic happening at the heart of water's transformation into precipitation in the atmosphere.

Take a snowflake and magnify it a few hundred times. Near the center of all those beautiful crystalline formations, you'll see a little speck of dirt or something. This is the nucleus. Water tends not to condense or freeze at appropriate temperatures unless it has a surface to get started on. Condensation and freezing nuclei provide that platform. If they did not exist, anyone wanting to draw water from the sky would have to invent them.

In fact, cloud seeding works on the principle that water will condense or freeze upon such particles. Add a few hundred thousands of such particles to a cloud, say the rainmakers, and you should get an increase in rainfall. It is hard to identify the precise results, but some researchers say seeded clouds rain more than unseeded ones, other things remaining equal.

The seeding aspect of the process is what intrigues Pueschel and his coworkers. If smoke adds particles to the atmosphere, might it not seed clouds downwind, altering precipitation patterns for many miles from the pollutant source? Put another way, might it not modify weather *inadvertently*? And what of the obverse? How does the environment change pollutants during their long drift through the lower atmosphere, where they are acted upon by sunlight and a host of intricate chemical processes?

Over the last several years, NOAA researchers have probed the plumes of pollutants spreading from power plants in New Mexico and Utah and Montana, refineries in Los Angeles, and Denver. Analysis of their findings has not always shown a clear "yes," that effluents do change downwind weather, but it strongly suggests such changes.

So, for this atmospheric chemistry team, St Helens seemed a rare opportunity

Rudolf Pueschel

Dr. Rudolf Pueschel, pilot George Clark, and engineer Dennis Wellman (l. to r.) at Yakima airport with their flying instrument platform Aeolus.

Aircraft begins to top summit of slumbering giant.

Photos, Rudolf Pueschel

"to look into one of nature's smokestacks," to use Pueschel's term.

"In a way, the volcano is like a huge powerplant, though how large a 'plant' it is we can't yet say," he explained early in April. "Many of the constituents emitted are identical to those emitted by burning coal, including sulfur dioxide, which causes haze and acid rain. We might expect to see an increase in the acidity of rainfall downwind of the volcano, much as we see acid precipitation in areas downwind of heavily industrialized areas."

On April 7, Pueschel and Dennis Wellman, the engineer who designed the intricately plumbed instrumentation and sampling systems used in this work, went to take a look at St. Helens' plume. Their probe was a twin-engined Aero Commander called *Aeolus,* after the ruler of the winds in Greek mythology. A battery of instrumentation in the airplane samples small particles, gases, and other constituents in the plume. Some of the quantities are worked out in flight; others must be drawn from more elaborate analyses back in Boulder.

Operating out of Yakima, Wash., about 80 miles east and a little north of St. Helens, the NOAA researchers would head for the controlled airspace around the volcano, which attracted small aircraft like a dirty marshmallow drawing flies. Initially, they worried that the plume would not be clearly visible—that it would be made up mainly of invisible gases. Not so, Pueschel says. "The plume was clearly visible about 80 miles downwind of the volcano, you could see it spreading along an inversion."

But what they found was not what they'd expected.

"First of all," he says, "St. Helens was unusually cooperative. We were in quite close, perhaps a few thousand feet away, when the volcano released large bursts of material. These gave us a very good chance to see what was in the plume."

What they saw, according to the NOAA scientist, was more ash coming out of the ruptured cone than smoke, "more dust and dirt than combustion products. St. Helens was behaving like a geyser. Water ran down through fissures in the mountain and was heated to a boil by magma there, then exploded upward in steam, carrying a lot of dirt and rock with it. The volcano wasn't hot enough inside to dissociate air, separate out the nitrogen,

NOAA Keeps Tabs On Mt. St. Helens

Immediately after the Mt. St. Helens eruptions on May 18, the National Weather Service Forecast Offices at Seattle, Wash. and Portland, Ore., began issuing flash flood and mud slide advisories. Travel advisories, air quality analyses, and special aviation advisories were also part of NOAA's armory of services to the public, warning of possible hazardous conditions resulting from the huge eruptions.

Severe stream flooding that occurred on the Toutle River west of Mt. St. Helens, caused by the mass of mud and snowmelt, was anticipated by a flash flood warning two to three hours in advance; the prompt action by NWS and quick work by local emergency service personnel enabled all 2,000 residents of the town of Toutle to be evacuated

In testimony before the Senate Appropriations Committee on June 10, Deputy Administrator James P. Walsh summed up much of the work of NOAA scientists, and ticked off some of the problems that the volcano had caused. For example, it has impaired the NWS ability to forecast flood conditions because many of the automatic stream gauges used to measure river and rainfall activity were lost. NWS is giving top priority to replacing them.

Also high on NOAA's priority list is determining current and future dangers to salmon and other river fish, Walsh said. The National Marine Fisheries Service has estimated that about $6 to $8 million in salmon stock was destroyed by mud and ash that poured into the Cowlitz and Toutle rivers.

He testified that NMFS does not yet know what impact alterations to the rivers in the area will have on anadromous fish—the fish that spawn in rivers, and spend much of the rest of their lives at sea. All the fish in the Toutle river

Suddenly a searing puff, seen from co-pilot's seat.

Then more violence, as ash and steam explode skyward.

and major tributaries were killed and the river rendered uninhabitable.

Immediate concern, Walsh said, is determining what effect the turbidity in the Cowlitz will have on the adult chinook and coho salmon that will return in the fall to spawn in the Cowlitz. As of June, NMFS scientists found that juvenile salmon returning were dying after six hours in the Cowlitz.

He said there is some evidence that fish from the Cowlitz are going to the Kalama river instead, but noted that fisheries experts do not know how widespread this change in migration might be.

The Environmental Research Laboratories also participated in the agency's efforts to understand the volcanic phenomena and predict their impacts. Short-term effects, say Air Resources Laboratories scientists, include dirty rain produced by rain clouds intersecting the dust plume; some obscuring and color change in the sun because of the volcanic ash, and brilliant sunrises and sunsets, owing to the scattering effect of the dust. Long term effects, ARL experts noted, may include possible warming of the lower stratosphere (50,000 to 70,000 feet) by a few degrees, and possible minor cooling of the lower atmosphere up to several tenths of a degree Celsius.

A global network of observatories operated by the Geophysical Monitoring for Climatic Change program is also monitoring the stratospheric plume of volcanic material, with an eye to assessing any possible unexpected effects of the material on the Earth's climate. One problem, say program scientists, is that the volcanic ash could confound efforts to detect climatic effects of human pollution. If Mt. St. Helens injected enough volcanic material high enough into the stratosphere, any temperature changes it causes would mask temperature changes caused by the increase in carbon dioxide resulting from human activities. This would likely rule out early detection of CO_2-induced temperature changes for perhaps the next 5 to 10 years.

and oxidize it into nitric oxide or nitrogen dioxide. It also wasn't melting down the minerals, so we saw very little in the way of sulfur dioxide and sulfates formed by oxidizing SO_2. Probably, although this awaits further analysis, there were no ammonium sulfates above what is normally present from the papermills of the area."

What about the aviation, as distinct from the science? Both Pueschel and Wellman are private pilots, with a wry appreciation of the fact that flying is, as someone said, a *very* creative act, referring to the propensity of aviation to surprise.

They found some turbulence in the plume. And, flying through the plume at a slow 120 miles an hour, the airplane sometimes was coated with an ochre skin of ash and debris. "When we accelerated for the trip home," Wellman remembers, "our instruments picked up the stuff blowing off the plane."

But the flights, which ended about April 12, are only the beginning of this NOAA study of St. Helens. Dr. Earl Barrett has begun a study of particle size distribution in the plume, an important element in determining the meteorological effects of airborne effluent. Using a scanning electron microscope and X-ray analyzer, Dr. Farn Parungo is looking at microscopic particles, blown up to baseball size, and extracting their inorganic composition. William Cobb of the Boulder laboratory is examining the airplane's recordings of electrical fields in the plume in a continuing study of the effects of pollutants—natural and otherwise—on electricity in the atmosphere. Dr. Russell Schnell is scrutinizing the sampled particles with an eye to measuring how effectively they seed downwind clouds.

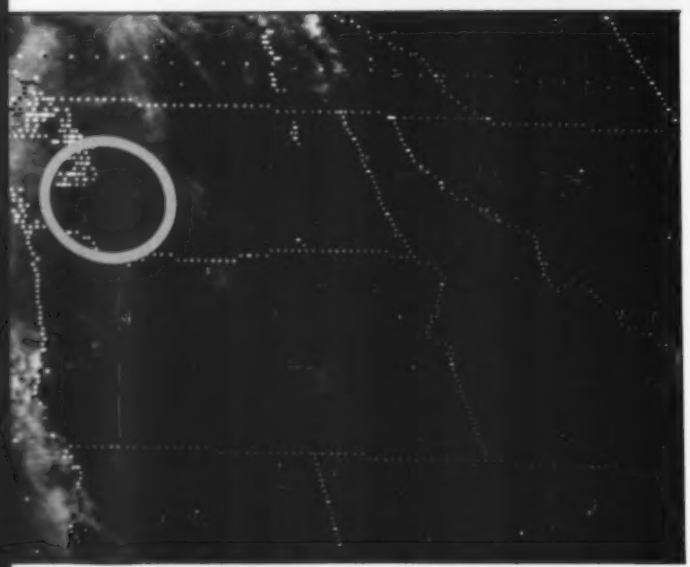
Meanwhile, Pueschel muses, with obvious excitement, on a return to St. Helens. "I'd like to go back if the activity changes. If it explodes, the plume will be greatly changed, the volcano will be more like a smokestack." Then NOAA researchers can compare "pollutants" from natural smokestacks more exactly with the fuming towers of industry.

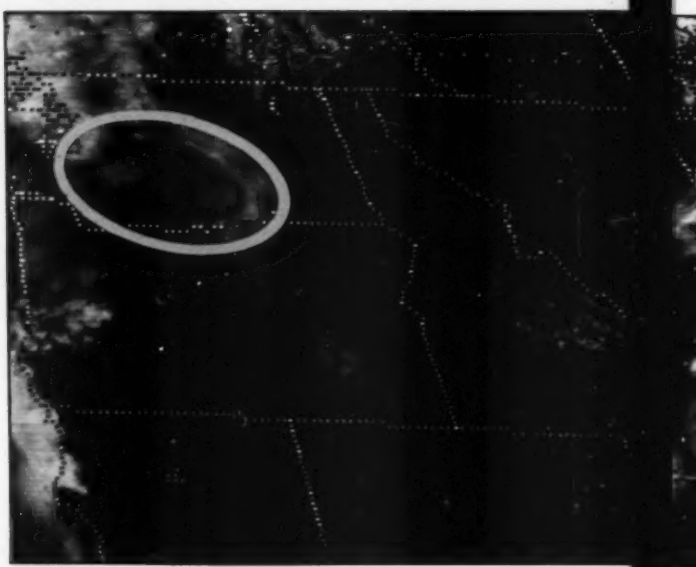
VIEW FROM SPACE

Reprise at Mount St. Helens

On May 18, a month and a half after its first burst of volcanic activity since last century, Mount St. Helens erupted violently, spewing ash and rock estimated at a minimum of 1.3 billion cubic yards into the atmosphere. The plume reached 60,000 feet in height, and the initial burst released the energy equivalent of between 10 and 50 megatons of TNT—as large as the largest nuclear bomb test ever conducted, by the Soviet Union in October 1961.

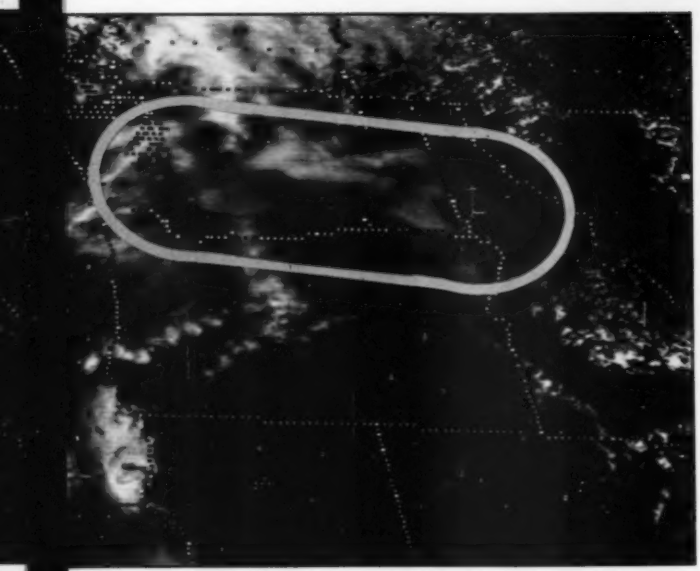
NOAA's GOES satellite captured a record of the huge explosion's aftermath, tracing the plume of ash throughout the day as it spread more than 600 miles in a great arc. The satellite photos below show the plume (left to right) at 8:45 Pacific Daylight Time, shortly after the

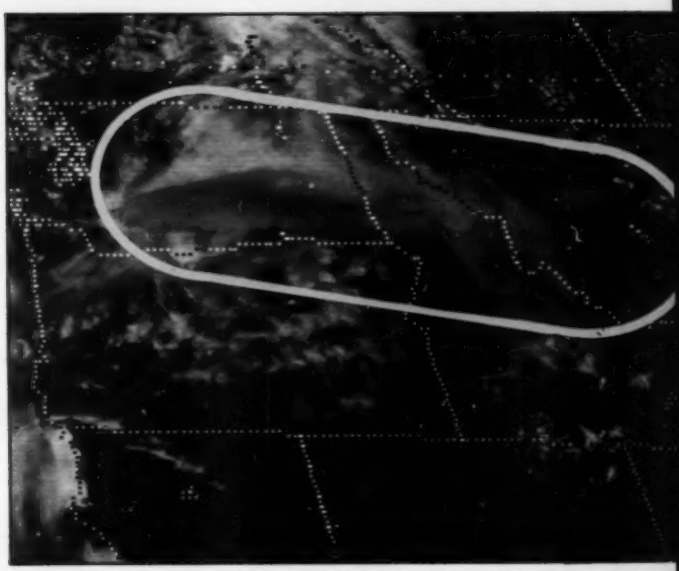




explosion; at 10:15 a.m., covering much of the central portion of the State of Washington; at 1:15 p.m., obscuring vast areas of Washington and part of Oregon, and reaching across the Idaho panhandle; and again at 4:45 p.m., covering western Montana and approaching Yellowstone National Park in northwestern Wyoming.

The aerial photographs, taken by Bob Krimmel and Austin Post of the U.S. Geological Survey, show (left) the early morning violence of the event, with clouds of ash and smoke pouring from the ripped-open crater and steaming material boiling down the side, and (right) at about noon, as the eruption continues and massive streamers of ash and steam are blown away to the northeast.





It was not a typical winter day in the Pacific Northwest. The sky overhead was bright blue with hardly a cloud, the early morning temperature just a bit above freezing with a warming trend promised for the afternoon.

Don Olson, Port Meteorological Officer in Seattle, Washington, put the last of his equipment in the compact car, his "traveling office", and began the trip to Everett some 30 miles north. On this particular day, Olson would visit six oceangoing freighters as part of NOAA's program to provide meteorological and oceanographic data for the forecasting and warning services of the National Weather Service and the worldwide meteorological network. In a typical year he visits more than 1,100 vessels.

Olson joined the Weather Service in 1951 in Stevenson, Washington, after serving in the U.S. Navy during World War II. In April 1952 he was assigned to Seattle for sea duty with the Pacific Weather Project and later transferred to the Lake Charles, Louisiana, airport weather station. He returned to the Pacific Weather Project, with more sea duty, in San Francisco, became the Port Meteorological Officer there, and then manager of the Missile Range Ship Program before his return to Seattle in 1972.

NOAA's weather ambassador, Don Olson, climbs long gangway to board automobile carrier MV Violet.

Services to ships in port

Harold Alabaster

Photos by the author

NOAA'S WEATHER AMBASSADOR

He was awarded the Commerce Department Bronze Medal in 1979 after receiving two consecutive outstanding performance awards in 1977 and 1978.

Olson and Capt. Arnold Reynolds of tug Wendy Foss *discuss chart of the day's weather forecast (above); Olson checks weather instruments aboard container ship* Siena.

Port Meteorological Officers, there are 13 stationed at ports in the United States, serve as part of the Cooperative Ship Weather Observing Program of the National Weather Service. This program is a continuation of an effort which began in 1946, shortly after World War II. Originally named the Pacific Weather Program, individuals assigned to this activity went to sea as "ship riders" collecting weather observation data, testing equipment, conducting atmospheric and oceanographic experiments, and providing forecasts for ship operations. Today's program is based both on national needs and international agreements.

Merchant ships are recruited by Port Meteorological Officers. These vessels become part of the Cooperative Ship Program and are asked to make daily observations at specific times while at sea. The collection of these reports, from the Great Lakes, Western North Atlantic and Eastern North Pacific Oceans, is accomplished through working agreements between the National Weather Service and U.S. Government and commercial shore radio stations. In turn, high seas and coastal marine reports are issued by the communications center at the National Meteorological Center, Suitland, Maryland. Great Lakes marine observations are disseminated by the Weather Service Forecast Office at Cleveland, Ohio.

Entering the Port of Everett, Olson receives a friendly recognition and "wave through" by the security guards. He threads his way through the warehouses, storage areas, cranes, and other portside equipment, to park his car beside the *Eastern Friendship*. This is the first of many vessels on his day's visit schedule. At the top of the gangway he is greeted by the ship's officer on duty and is escorted to the bridge.

This particular vessel happens to be on its maiden voyage, a fact reflected by its new equipment, fresh paint, and an overall aura of newness. The vessel's master is Captain Elias Lee. He and the entire crew are from the Philippines. Longshoremen are busy loading logs. When they finish, from 18,000 to 19,000 tons—7 million board feet—will have been brought on board. Lee's reception of Olson is most friendly; he is delighted to have an opportunity to show his visitor his new ship.

While the ship is new, Lee, at 31, is a veteran of many years of sailing the Pacific Ocean. He is particularly pleased to have a copy of the current weather forecast, a new pilot chart, and other documents Olson has brought along for distribution to the ships he visits. Olson will also check the ship's barometer and affix a dated calibration sticker. He performs this service on every ship he visits and, if needed, calibrates other meteorological instruments, enhancing the accuracy of the periodic reports they provide.

All cooperating ships are requested to make and record four 6-hourly observations every day while at sea. Special observations are also made when requested by a National Weather Service Forecast Office, the National Hurricane Center or when the ship encounters severe weather conditions such as ice or tropical storms. The ship's radio officer transmits these observations to selected shore radio stations for relay to the National Weather Service. The completed observation forms are ultimately sent to the Environmental Data and Information Service's National Climatic Center, where they are used for climatological purposes. During the 4-month period from November 1978 through February 1979, an average of 105,000 radio reports were received from ships of all nations, including Ocean Weather Stations. Each Port Meteorological Officer receives a periodic computer tabulation of these reports, indicating the ship's name, reporting times, and the number of reports made.

His visit to *Eastern Friendship* completed, and there being no other vessels at dockside in Everett on this particular

day, Olson returns to Seattle to continue his visits. On the way to the Seattle waterfront, Olson makes a detour to the headquarters of the Foss Launch and Tug Company, one of the major tug companies in Seattle. There he delivers the latest marine forecast chart to the operations room, where the radio operator is in contact with the many vessels, both in port and at sea, throughout the area. A brief meeting with the Port Captain for Foss, Tim Lyness, discloses that one of their vessels, the *Wendy Foss,* in approximately an hour will be making a trip to the western shore of Vancouver Island in Canada. The skipper, Captain Arnold Reynolds, a veteran of 41 years at sea, invites Olson on board.

A real seagoing tug, the *Wendy Foss* is 120 feet long, has a gross of 234 tons, and has 3,000 horsepower available to take the large barges it pulls through almost any kind of weather conditions. Captain Reynolds is particularly interested in a low pressure system located some 1,000 nautical miles off the Washington coast. It will be some time, perhaps even days, before the low reaches the coast. However, with a fully loaded barge, the *Wendy Foss* makes 8.5 knots, and at that speed the weather several days ahead is an important consideration.

Olson calibrates the ship's barometer, checks the supply of forms and other materials, and accepts the Captain's invitation for a cup of "real coffee." The conversation moves from ships to weather and back again. Olson, having been a shiprider with the Pacific Weather Program, fully appreciates the mariner's problems. Captain Reynolds and the other seamen in turn appreciate being able to discuss those problems with an individual of his experience and background.

Piers 90 and 91 are the next stop on Olson's rounds for the day. It is a short drive from Foss Launch and Tug Company on Lake Union to the northernmost piers on the Seattle waterfront. These facilities —long, spacious piers—are, in the main, used for the delivery of imported automobiles. Today the *MV Violet* is in port offloading several hundred compact cars. As Olson drives down the long rows of parked automobiles, a large sign indicates their ultimate delivery location: Chicago, St. Louis, Houston, and other cities to the east.

The *MV Violet* appears to the casual observer quite different from the other merchant vessels seen in and around the port. It is especially designed as an automobile carrier with a square hull and decks high above the waterline. The steep gangway with some 64 steps to the quarter deck is ample testimony that a Port Meteorological Officer had better be in good physical condition.

MV Violet's *Second Officer reviews ship's course records during storm crossing as Olson looks on.*

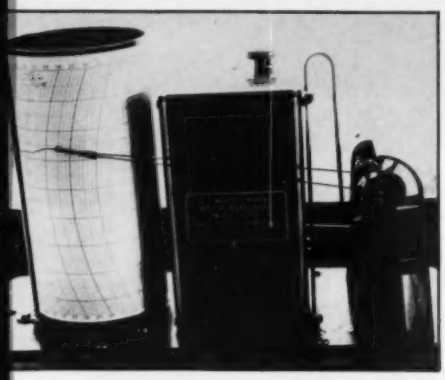
Three years old, *MV Violet* is a modern and well-cared-for vessel. Its bridge is spotless and its Master Mariner, Captain Chan Chi-Sheung is dressed in a navy blue uniform with white shirt, black tie and four gold stipes on the sleeve of his coat. He has been in charge of this ship since its maiden voyage.

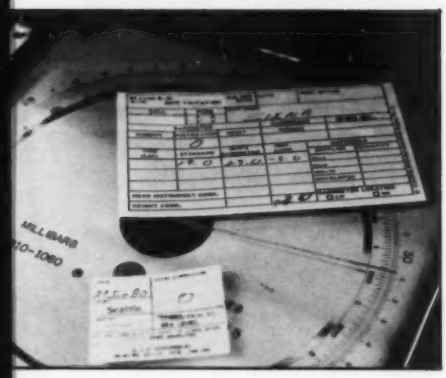
The Captain and Second Officer Chang Ting-Hsing are reviewing their most recent passage when Olson arrives. Both speak fluent English, and, after Olson completes his inspection of the ship's weather instruments, both are most eager to discuss the unusually bad storm encountered a week before the ship's arrival in Seattle. On January 23, while crossing the international dateline, the vessel passed through a low pressure system which produced a reading of 945 millibars (27.90 inches). This extremely low pressure system was accompanied by high winds, which on more than one occasion reached 60 knots, developing high seas and forcing the ship into a 37 degree roll. All these facts had been reported via radio. They were also precisely recorded on the ship's Weather Observation Report forms.

Collecting the completed reports, Olson replenishes the supply. He also leaves a copy of the day's weather chart, which just incidentally also shows a low system developing off the coast, an important factor since the ship is scheduled to depart the next day.

The weather in the North Pacific is not a mariner's paradise. The long stretch of ocean from Japan east to the Gulf of Alaska and the Pacific Northwest Coast provides ample opportunity

Container ship Siena *boasts a recording barometer from the days of the U.S. Weather Bureau (above); Olson's record-keeping includes these forms completed during ship visit.*





for weather systems to build to storm levels. These storms most often follow the same routes that shipping vessels must take. The weather is best characterized by an often rapid succession of high and low pressure systems. These can serve to reinforce each other. The high altitude jet stream, an important factor to aviation, is also created by these swiftly moving forces. Pacific weather can also affect the fishing industry. Ships can freeze over and sink beneath the weight of the ice, and fish movements are directly influenced by weather. Dr. Douglas McLain, a scientist working in NOAA's Pacific Environmental Group, recently noted, "Mild conditions in Alaskan waters during recent winters have allowed a remarkable recovery of salmon stocks from their earlier depressed condition, following a series of severe winters there in the early 1970's." Cold Bay, Cape Decision, Resurrection Bay, Cape Disappointment, and Destruction Island —all are names of locations along the coast of Alaska and the Pacific Northwest, continuous reminders to mariners of this region's fierce weather.

Leaving the *MV Violet,* Olson next visits two container ships, the *Incontrans Speed* and the *Siena,* berthed in the heart of the Seattle waterfront. Both vessels are attended by cranes unloading trailer-sized boxes full of the "stuff" of ocean commerce. Even though it is close to noon, the activity continues. The *Siena,* of Danish registry, has 745 containers to offload in Seattle and California ports.

The crew of the *Siena* are particularly conscientious about making their weather observations. The vessel, a participant in the U.S.-managed portion of the formal Cooperative Ship program, has been designated a "selected" ship. As such, it is equipped with a National Weather Service recording barometer. Ships given this status sail routes where they can be visited by a Port Meteorological Officer at least once every six months. In addition to checking the instrument's accuracy, Olson collects the daily charts. These, along with the forms recording other readings taken by the crew, have a key function in the development of climatological data to be used in connection with marine weather forecasting.

There are four major ports in the Pacific Northwest area covered by Olson: Seattle, Tacoma, and Everett in the State of Washington and Portland, Oregon, to the south. In addition, there are the smaller but equally important ports on the Columbia River as well as Longview, Port Angeles, and Aberdeen in Washington. In 1978 more than 2,500 ships visited the Puget Sound area. That year, the Port of Seattle was the West Coast's number one container port and the sixth busiest container port in the world. The Port of Tacoma was visited by 971 vessels in 1978 with cargos totaling almost 5.5 million tons. In 1979, almost 349 million board feet of logs, 24 million board feet of lumber, 287,000 tons of alumina, and 8,000 short tons of wood pulp moved through the Port of Everett. To the south, in Portland, Oregon, more than 1,400 merchant ships made port calls in 1979, under 33 flags, and carrying 6.4 million short tons.

The magnitude of the activity at these various facilities is ample testimony to their importance to the overall commerce of the United States. To the degree that weather affects these activities, the National Weather Service and the Port Meteorological Office play a vital role.

Though late in the day, there is still time for one more visit before Olson returns to his office. The *Hellespont Conquest* is offloading the last of its cargo. This ship is a bulk carrier, a "tramp steamer" in the maritime industry's terms. It is a misnomer. The ship's power is not steam, and the vessel does not fit the popular concept of a "tramp." She is clean, fairly modern, and her crew handles her in a most serious and business-like manner. On this ship Olson finds his first real surprise of the day. The Chief Mate, Sten Stenson, is a friend. They had met some two years ago on a previous visit, and their warm handshake reflects the unique relationships that develop in the world of maritime commerce.

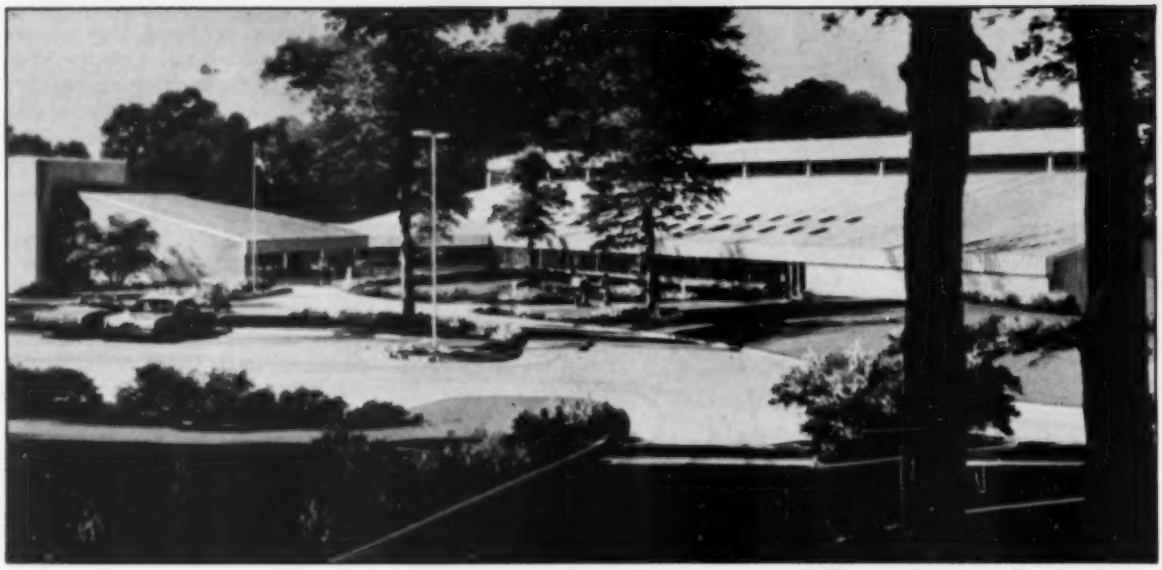
Upon the completion of his inspection and check of the ship's equipment, Olson and Stenson get together for a cup of coffee in the Smoking Room. They exchange the details of the past years, words about their families, and they chat about past events. Stenson's contract enables him to have his family on board as does the ship Captain's. This appears to be true of many tramp steamers since they spend long months going from port to port and returning only occasionally to what may be called home.

Were it not for the evening sailing time, Olson and Stenson might have been able to get together for dinner. Perhaps next time, but, for now, Olson's day is just about over. He will return to the office, go over the materials and information he has collected, and prepare them for forwarding. He will also review the next day's shipping schedule. By that time, Captain Lee's ship will be well on its way back to the Far East loaded with logs, Captain Reynolds and the *Wendy Foss* will still be enroute to the western side of Canada's Vancouver Island, the *MV Violet* will be headed farther south to unload the remainder of its cargo of automobiles, and the *Siena* will be outbound at the entrance to the Strait of Juan De Fuca ready for a turn to port on a heading for California ports and then off to southeast Asia.

To a significant degree, all have a common interest and concern for the weather. Beyond that they share a feeling of cooperation and friendship characteristic of all individuals whose daily lives bring them into contact with the seas. ●

CITY-SCAPE

City of History



Roland Paine

"Charles Town, as it was originally called, was settled in 1670 where the Ashley and Cooper Rivers meet to form the Atlantic Ocean." So says the famous picture post card of Charleston, S.C., and who is NOAA to argue? The NOAA photoplane view (opposite page) shows the confluence of the Ashley (1) and Cooper (2) rivers leading to the outer harbor; the famous battery (3) is now a park still guarded by the venerable coast artillery mortars (left). NOAA visitors to Charleston on their way to the Marine Resources Center (4), where both the new National Marine Fisheries Service laboratory (above) and the Sea Grant programs are located, may also have occasion to see the U.S.S. *Yorktown* (5) at her permanent mooring, or visit the city's beautiful historic district (6).

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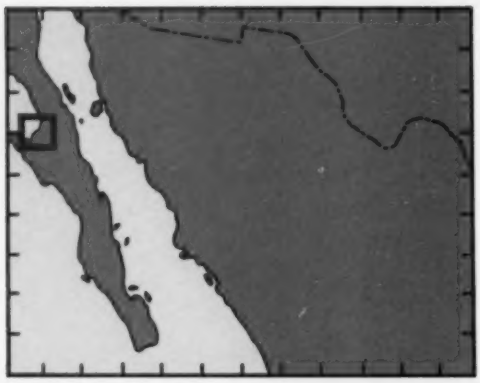
Research on gray whales

LEVIATHANS IN SCAMMON'S LAGOON

David Withrow
Photos by the author



Laguna Ojo de Liebre, or Scammon's Lagoon, right: Joint U.S.-Mexican gray whale research team set up camp (below) on the shore of the lagoon.

The deep, resonating blows of the California gray whale played obligato to coyote barks and bird chatter. When we awakened, it was 6 a.m., time to dress, gulp a coffee, and climb 20 feet up the observation tower for the morning's first whale watch.

Pregnant gray whales were beginning to arrive in the waters of Baja California, Mexico, where they would deliver and tend their calves. It was early January. By mid-March, most of the cows, calves in tow, would have left for their arctic feeding grounds.

Our research centered around Scammon's Lagoon (Laguna Ojo de Liebre), the largest of the California gray whale's three major breeding and calving areas. The five-year study, now entering its third year, is sponsored by NOAA (National Marine Fisheries Service, National Marine Mammal Laboratory, Seattle) and PESCA, the Mexican Department of Fisheries. Our research team at last January's field season consisted of five U.S. biologists from NOAA-NML, three Mexican biologists from PESCA, and one Mexican graduate student from the University of Washington.

We are collecting baseline information on habitat usage by gray whales in an area where there is still only minimal human disturbance. We are monitoring whale numbers, movement, and behavior and looking for harassment and other factors that could affect the ecology of the species. Ultimately, we will make recommendations to protect this endangered leviathan.

Jim Johnson tags whale with color-coded streamer as Dave Withrow operates small boat.

Each year, gray whales migrate nearly 10,000 miles, from the cold arctic feeding grounds where they spend the summer to the warm quiet waters of Baja California. Here, they breed, give birth, and nurse their young, undisturbed by predators. However, it wasn't always this way. In 1857-58, whaling captain Charles Scammon discovered the entrance to Laguna Ojo de Liebre. Hundreds of whales, including calves, became easy prey for whalers' harpoons and bomb-lances in this and other secluded bays of Baja California. So many whales were killed so quickly that by 1860-61, less than 4 years after it had begun, whaling in Scammon's Lagoon was considered unprofitable.

Gray whales are thought to have once numbered about 15,000, before Scammon's find. During the early 1900's, the low point, there were probably only 4,000 whales. Today, Scammon's Lagoon is a unique environment, with a denser whale concentration than anywhere else in the world; in just one day's boat survey, we counted over 1,300 of them.

The gray whales were first protected under a 1936 convention, and in 1947, the International Whaling Commission (IWC) prohibited commercial taking of them. Today the gray whale population may have returned to its pre-exploitation level. Gray whales are classified as a sustained management stock by the IWC, and the annual catch limit of 179 is reserved solely for the subsistance use of American and Soviet Eskimos.

Two NOAA-NMML gray whale counting stations—one at Monterey, Calif., which has made 13 annual counts, and the other at Cape Sarichef, Alaska, which has made 2 counts—working independently, in 1979 estimated the gray whale population at 16,000, give or take 3,000 animals.

Gray whale tail fluke; parallel lines on left edge, team surmised, were made by killer whale during fight.

Though apparently doing well, gray whales may be highly vulnerable to many environmental changes brought about by population growth and industrialization. Two major concerns are the possible impact of oil leases along the migration route and increasing harassment by tourists.

Scammon's Lagoon, the largest and most heavily populated of the three major calving areas, was declared a Mexi-

can National Wildlife Refuge in 1972, protecting the gray whale and limiting tourist vessel traffic. The other two, San Ignacio Lagoon and Magdalena Bay, are located 150 miles and 375 miles south, respectively. Scammon's Lagoon contains many shallow, twisting channels separated by broad tidal flats. These channels, extending over 30 miles into the arid Vizcaino Desert offer protection from the region's heavy winds. The 225-square-mile surface area of Scammon's Lagoon is almost halved at low tide. We had to plan all activities with the 4- to 6-foot tidal difference in mind. By finding ourselves high and dry, we learned to anchor out near the edge of the sand bar when we wanted to use a boat at low tide.

Our camp was situated near the north central portion of the lagoon, 25 miles from the small company town of Guerrero Negro. The town is the home of Exportadora de Sal, the world's largest salt company, evaporating and processing nearly 7 million metric tons of salt a year.

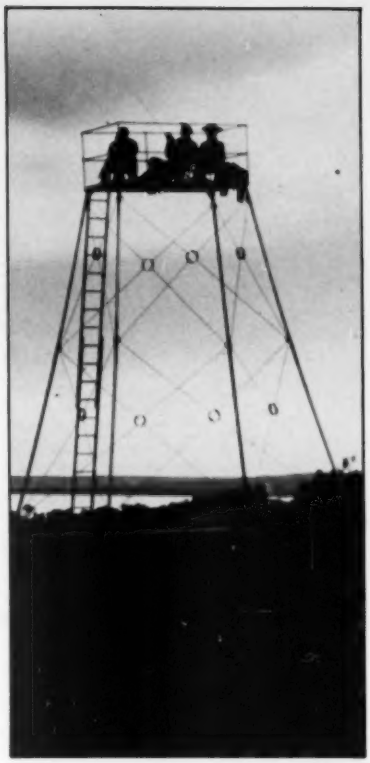
We made weekly trips to town to shower, purchase gas and water, and check the post and telegraph offices for news and mail from the northland. Our hour-and-a-quarter trip over a pot-hole riddled trail was rewarded with a shower at the public bath and a meal of fish tacos from our favorite street vendors.

Our work schedule ran in 6-day cycles. Each week, 2 consecutive days were allotted to counting whales from the tower, 2 days to boat surveys throughout the lagoon, and 2 days for miscellaneous experiments and a bad weather allowance. Among the miscellaneous projects were charting the lagoon, taking depth recordings, measuring dead or stranded animals, and conducting necropsies on all fresh specimens.

Numerous photographs were taken for an identification catalog of individual whales to spot their movements between and within lagoons. Researchers in other areas are contributing photographs for this catalog.

Fixed-wing aircraft were used to census whales inside the lagoons and along the coast of Baja between lagoons. Experiments were conducted to compare the relative accuracy of land, boat, and aerial counts.

To find out whether gray whales stay in the same place within the lagoon, move from area to area in recognizable patterns, or move about randomly, we mark animals. Marking is especially difficult in whales. Built to move smoothly and fast through deep water, the whale's muscles and water friction work together to dislodge anything that becomes embedded below layers of protective fat. For this reason, and because whales are extremely sensitive to tranquillizers used to immobilize other mammals for implants, widespread use of telemetry monitors has proven impractical for anything but friendly whales.



Observation tower at Scammon's Lagoon, with team members searching for whales.

Cindy D'Vincent taking data on stranded whale calf.

Last season we marked 29 adult whales in an exploratory study to develop a technique for implanting external streamer tags and to see how long the tags would remain implanted. Our streamers were made of color-coded nylon 4.5 inches wide by 3 feet long. They were rolled into a hollow shafted arrow and implanted by means of an 80 pound crossbow. The stainless steel leader and anchor tip were sprayed with a disinfectant and penetrated only the blubber layer, about 1.5 to 2 inches deep.

Most animals reacted to tagging with nothing more than a flinch, much like most adults receiving an injection, and no difference in their behavior was noticed afterwards. We hoped the tag would stay put for a month. Due to a heavy storm, we managed to resight only four tagged whales from the observation tower. The longest interval between tagging and resighting was 18 days. One marked animal was reported by fishermen a month later in Laguna Manuela, about 55 miles north of the tagging site.

Tagging was not attempted this year, due in part to a scheduling change, weather, and the late arrival of the whales. However, we were able to obtain some valuable information on movement, time of calving, and date of departure from one conspicuously marked whale. This animal, nicknamed "hunchback" of Scammon's Lagoon could easily be distinguished from all other whales by her greatly enlarged first dorsal hump. From seven resightings, we know that she calved between January 26, 1980 and February 6, and that she probably left the lagoon on her migration north on February 25.

This study is invaluable for our understanding of the gray whale. In addition, knowledge of its biology and behavior and improvements in our sampling techniques may find applications in the conservation of other endangered whale species. ●

Italian dishes are well known for their wonderful blend of flavors, their pungency and their fascinating aromas. Coupled with the long-time American favorite, crab, Italian cuisine creates new delights in the kitchen. Here are three elegant recipes, two with pasta and one a salad, that will truly enhance your summertime repasts, indoors or al fresco!

Crab Feast From Sunny Italy

CRAB SAUCE WITH SPAGHETTI

1 pound crab meat; fresh, frozen, or pasteurized
or
3 cans (6½ or 7½ ounces each) crab meat
2 cloves garlic, finely chopped
2 tablespoons chopped parsley
¼ cup butter or margarine, melted
1 cup canned tomatoes
1 can (ounces) tomato sauce
¼ teaspoon salt
½ teaspoon paprika
Dash pepper
3 cups cooked spaghetti
Grated Parmesan cheese

Thaw frozen crab meat. Drain crab meat. Remove any remaining shell or cartilage. Cut crab meat into ½ inch pieces. Cook onion, celery, garlic, and parsley in butter until tender. Add tomatoes, tomato sauce, and seasonings. Simmer for 20 minutes, stirring occasionally. Add crab meat; heat. Serve over spaghetti. Garnish with cheese sprinkled over the top. Serves 6.

STUFFED MANICOTTI WITH CRABMEAT SAUCE

1 can (7½ ounce) crabmeat
1 cup coarsely chopped onion
1 clove garlic, minced
2 tablespoons cooking oil
1 can (1 pound) tomatoes
1 can (8 ounce) tomato sauce
1 teaspoon basil
¾ teaspoon salt
8 (4 ounce) manicotti
1½ cups large curd cream-style cottage cheese
¾ cup shredded or grated Parmesan cheese
1 egg, beaten
2 tablespoons chopped parsley

Drain and flake crabmeat; set aside. Cook onion and garlic in oil until onion is limp. Add tomatoes, tomato sauce, basil and ½ teapsoon salt. Bring to simmering stage; simmer gently, uncovered, until thickened, about 25 to 30 minutes, stirring as needed. Stir crabmeat into sauce. Spread ⅓ of the sauce over bottom of shallow 1½ quart casserole. While sauce is cooking cook manicotti as directed on package label; drain and rinse in cold water. Combine and mix cottage cheese, ½ cup Parmesan cheese, egg, parsley, and remaining ¼ teaspoon salt. Fill manicotti shells with equal amounts of cheese mixture and arrange on sauce in casserole. Spoon remaining sauce over filled manicotti. Cover dish with aluminum foil, crimping it to edges of dish. Bake in moderate oven, 350° F., 25 minutes. Uncover and bake 15 to 20 minutes longer or until manicotti is hot and tender. Sprinkle remaining ¼ cup Parmesan cheese over top when removed from oven. Makes 4 servings.

CRAB STUFFED AVOCADOS

1 pound crab meat, fresh or frozen
or
3 cans (6-13 ounces each) crab meat
2 tablespoons flour
¼ teaspoon salt
Dash pepper
2 tablespoons melted fat or oil
1 cup milk
¼ teaspoon Wrocestershire sauce
2 tablespoons chopped olives
2 tablespoons chopped pimiento
3 ripe avocados
¼ cup grated cheese

Thaw frozen crab meat or drain canned crab meat. Remove any remaining shell or cartilage from crab meat. Blend flour, salt, and pepper into fat. Add milk gradually and cook until thick and smooth, stirring constantly. Add Worcestershire sauce, olives, pimiento, and crab meat. Cut avocados in half and remove seeds. Fill centers with crab mixture and sprinkle cheese over top. Place in a well-greased baking pan. Bake in a moderate oven, 350° F., for 20 to 25 minutes, or until brown. Serves 6.

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